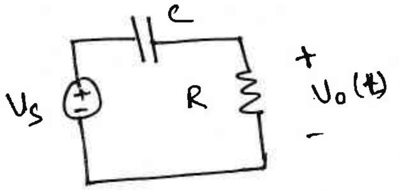
1



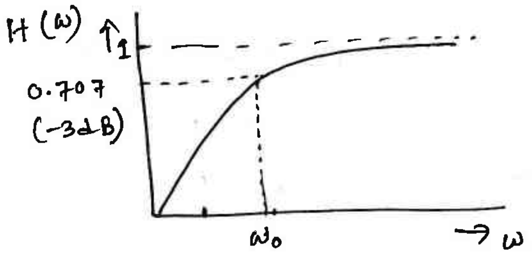
$$H(\omega) = \frac{V_o}{V_s} = \frac{R}{R+\frac{1}{j\omega C}} = \frac{j\omega RC}{1+j\omega RC}$$

$$\left|\frac{V_o}{V_s}\right| = \frac{\omega RC}{\sqrt{1+\omega^2R^2C^2}} = \frac{1}{\sqrt{2}}$$ at cut-off freq. (ω_0)

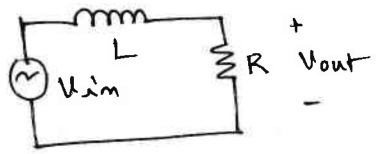
$$\therefore \omega_0^2R^2C^2 = 1 \;;\quad \therefore \omega_0 = \frac{1}{RC}$$

High pass filter

$$\therefore H(\omega) = \frac{j(\omega/\omega_0)}{1+j(\omega/\omega_0)}$$



2



Transfer function $H(\omega) = \frac{V_o}{V_s} = \frac{R}{R+j\omega L}$

$$\therefore \left|\frac{V_o}{V_s}\right| = \frac{R}{\sqrt{R^2+\omega^2L^2}} = \frac{1}{\sqrt{2}}$$ at $\omega = \omega_0$ (cut-off)

$$\omega_0 = \frac{R}{L}$$

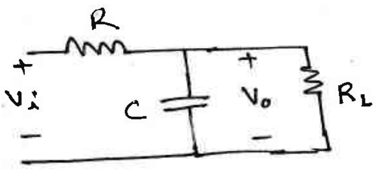
$$\therefore f_0 = \frac{R}{2\pi L}$$

$f_0 = 5$ kHz, $L = 40$ mH.

$$\therefore R = 2\pi f L = 2\times 3.14\times 5000\times 40\times 10^{-3}$$

$$R = 1.256 \text{ k}\Omega$$

3



$$H = \frac{V_o}{V_i} = \frac{R_L \| \frac{1}{j\omega C}}{R + R_L \| \frac{1}{j\omega C}}$$

$$= \frac{R_L}{R+R_L+RR_Lj\omega C}$$

$$\frac{V_o}{V_i} = \frac{\frac{RR_L}{(R+R_L)R}}{1+j\omega C\frac{RR_L}{R+R_L}} = \frac{R'/R}{1+j\omega CR'} \quad \text{— (a)}$$

where, $R' = R \| R_L = \frac{RR_L}{R+R_L}$

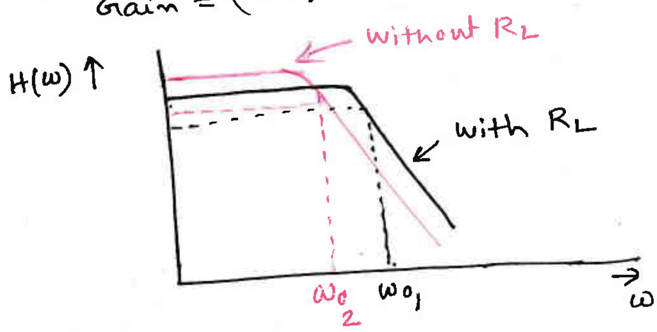
Low pass filter — (b)

$$|H| = \frac{(R'/R)}{\sqrt{1+\omega^2C^2R'^2}} = \frac{1}{\sqrt{2}}$$ at $\omega = \omega_{01}$ cut-off.

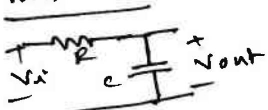
$$\therefore \omega_{01}^2C^2R'^2 = 1$$

$$\omega_{01} = \frac{1}{CR'} \quad \text{— (c)}$$

$$\text{Gain} = (R'/R) \quad \text{— (c)}$$



without R_L,



For this filter: Gain = 1

$$H' = \frac{\frac{1}{j\omega C}}{R+\frac{1}{j\omega C}} = \frac{1}{1+j\omega CR}$$

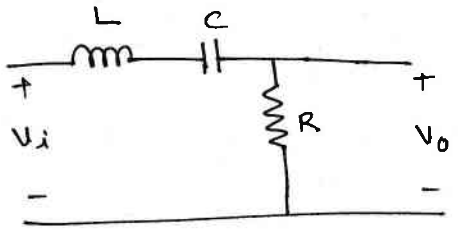
Low pass filter, with cut-off freq. $\omega_{02} = \frac{1}{CR}$, as $R > R'$, $[R' = R \| R_L]$

$\omega_{01} > \omega_{02}$,

with R_L, Gain $= \frac{R'}{R} < 1$

So, gain reduces due to R_L but, cut-off freq. increases.

(4)



Band width (BW) $= f_{upper} - f_{lower}$

$\therefore 3\,KHz = f_{upper} - 1\,KHz.$

$\therefore f_{upper} = 4\,KHz.$

BW in rad/Sec $= 2\pi\, BW(Hz) = 1.88\times10^4$ rad/s

$\omega_{upper} = 2\pi f_{upper} = 2.51\times10^4$ rad/sec

$\omega_{low} = 2\pi f_{lower} = 6.28\times10^3$ rad/sec.

$\therefore \omega_0 = \sqrt{\omega_{upper}\times\omega_{lower}}$

$= 1.26\times10^4$ rad/Sec.

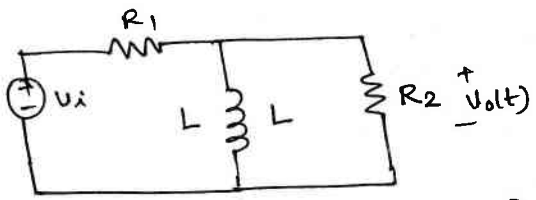
$\omega_0 = \frac{1}{\sqrt{LC}}$; $LC = \frac{1}{\omega_0^2}$ $\therefore$ $C = \frac{1}{\omega_0^2 L}$; $L = 10$ mH. (let). (design value)

$\therefore C = 0.63\,\mu F.$

$\therefore BW = \frac{\omega_0}{Q}$; $Q = \frac{1.26\times10^4}{1.88\times10^4} = 0.67$.

$Q = \frac{\omega_0}{R/L}$; $R = \frac{\omega_0 L}{Q} = BW\cdot L = 188\,\Omega$.

(5)



$H(\omega) = \frac{V_o}{V_i} = \frac{R_2 \| j\omega L}{R_1 + R_2\| j\omega L}$

$= \frac{\frac{R_2 j\omega L}{R_2 + j\omega L}}{R_1 + \frac{R_2 j\omega L}{R_2 + j\omega L}}$

High pass Filter, as
'ω' very low, $H(\omega)\to 0$
'ω' very high, $H(\omega)\to \frac{R_2}{R_1+R_2}$

$= \frac{R_2 j\omega L}{R_1R_2 + j\omega L R_1 + j\omega L R_2}$

$H(\omega) = \frac{j R_2 \omega L}{R_1R_2 + j\omega L(R_1+R_2)} = \frac{R_2}{R_1+R_2}\left[\frac{j\omega L}{\frac{R_1R_2}{R_1+R_2} + j\omega L}\right]$

$H(\omega) = \frac{R_2}{R_1+R_2}\left[\frac{1}{1 - j\frac{R_1R_2}{\omega L(R_1+R_2)}}\right]$

At, ω_0, $|H(\omega)| = \frac{1}{\sqrt{2}}$ $\therefore 1 + \frac{R_1^2R_2^2}{\omega_0^2 L^2 (R_1+R_2)^2} = 2.$

Cut-off freq.

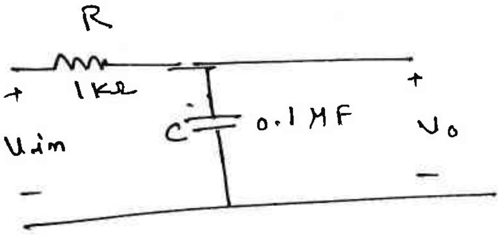
$\therefore \omega_0 = \frac{R_1R_2}{L(R_1+R_2)}$

$R_1 = R_2 = 100\,\Omega$, $L = 2$mH

$\omega_0 = \frac{100\times100}{2\times10^{-3}(100+100)}$

$\omega_0 = 25$ krad/Sec.

(6)



Cut-off frequency $f_0 = \frac{1}{2\pi RC}$

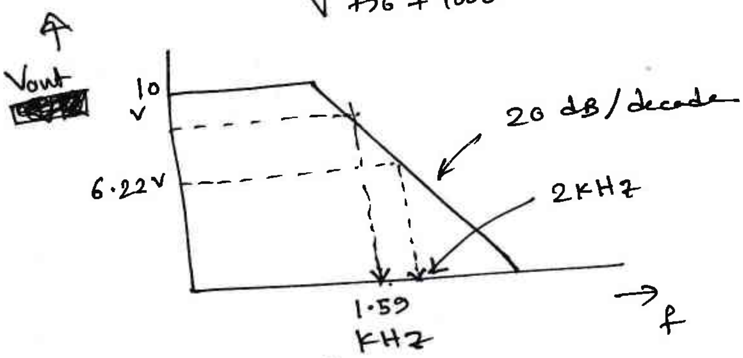
$$f_0 = \frac{1}{2\pi \times 10^3 \times 0.1 \times 10^{-6}}$$

$$= 1.59 \text{ KHZ.}$$

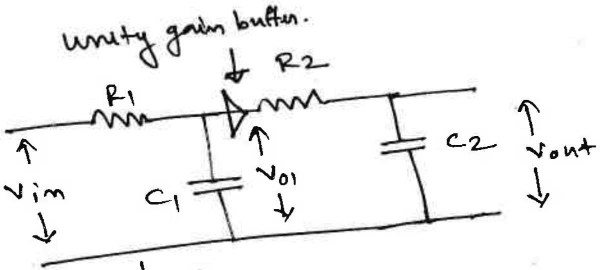
$$V_{out}\ (2\text{KHz}) = \frac{|X_C|}{\sqrt{R^2 + X_C^2}} \times V_{in} \quad , \quad V_{in} = 10V \text{ @ } 2\text{KHz.} = f$$

$$X_C = \frac{1}{2\pi f c} = 796\ \Omega$$

$$V_{out} = \frac{796}{\sqrt{796^2 + 1000^2}} \times 10 = \underline{6.22V.}$$



(7)

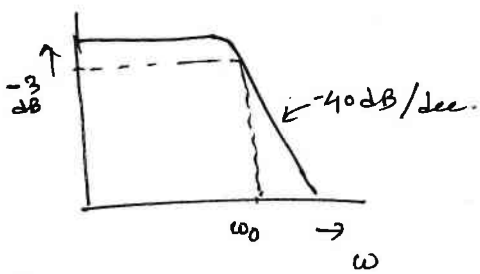


$$V_{01} = \frac{\frac{1}{j\omega C_1}}{R_1 + \frac{1}{j\omega C_1}} V_{in}.$$

$$V_{01} = \frac{1}{1 + j\omega C_1 R_1} V_{in}$$

$$V_{out} = \frac{\frac{1}{j\omega C_2}}{R_2 + \frac{1}{j\omega C_2}} V_{01} = \frac{V_{in}}{(1 + j\omega C_2 R_2)(1 + j\omega C_1 R_1)} = \frac{V_{in.}}{1 + j\omega(C_1R_1 + C_2R_2) - \omega^2 C_1 C_2 R_1 R_2}$$

$$\therefore \frac{V_{out}}{V_{in}} = \frac{1}{1 + j\omega(C_1R_1 + C_2R_2) + \omega^2 C_1 C_2 R_1 R_2}$$



Low pass filter (2nd order).

Cut-off frequency $= \omega_0 = \frac{1}{\sqrt{C_1 C_2 R_1 R_2}}$

Roll-off at −3dB frequency = −40 dB/decade.